FAUNA OF *DROSOPHILA* (DIPTERA, DROSOPHILIDAE) IN THE NORTHERN AREA OF THE "CADEIA DO ESPINHAÇO", STATES OF MINAS GERAIS AND BAHIA, BRAZIL: BIOGEOGRAPHICAL AND ECOLOGICAL ASPECTS

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ABSTRACT

Drosophila fauna from the northern area of the "Cadeia do Espinhaço", Brazil is described based on data from 33,985 individuals belonging to 23 species. A total of 28, 796 adults were collected with baits and 5,189 cactophilic individuals were collected at immature stages in cactus species along with the cladode of the host cactus. The occurrence of each species is discussed in biogeographical and ecological terms. It is the first record of the larvae breeding site for both, the endemic South American species and the introduced species.

KEYWORDS. "Cadeia do Espinhaço", highlands, biodiversity, *Drosophila* spp.

INTRODUCTION

The "Cadeia do Espinhaço" is formed from an area of terrain aproximately 1,000km long and between 50 and 100km broad, and is upwards of 800m above sea level. Its southernmost limit is the "Serra do Ouro Branco", south of the city of Ouro Preto, in Minas Gerais (MG), Brazil; it runs northwards into the state of Bahia (BA), and forms the watershed of the tributaries of the right bank of the São Francisco River, which flows to the Atlantic (MOREIRA, 1965). This mountainous area has for the most part shallow sandy soils with rocky outcrops (JOLY, 1970). The structure of the "Cadeia do Espinhaço" is Pre-Cambrian (ABREU, 1984). The predominant vegetation is rocky fields (GIULIETTI & PIRANI, 1988) with areas of "cerrados" and "caatingas" (brushwood), and near the rivers, marshes and woods.

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The results of collections carried out in the northern area of "Cadeia do Espinhaço" are discussed in this work, continuing the inventory of *Drosophila* species found in South America (DOBZHANSKY & PAVAN, 1943; PAVAN & CUNHA, 1947; PAVAN, 1959; SENE **et al.**, 1980; VAL **et al.**, 1981; VILELA **et al.**, 1983; TIDON-SKLORZ **et al.**, 1994).

MATERIAL AND METHODS

The sites and dates of the collections are summarized in table I. All the sample points are in high altitude grasslands, the majority with intermediate characteristics between rocky fields, caatingas and cerrados.

Table I. Locations of the *Drosophila* collections carried out in the northern area of the "Cadeia do Espinhaço" (BA = Bahia; MG = Minas Gerais). All collections were made in 1990 during August, except for the D54 (in February).

code	localities	altitude (m)	type of collection
D54	Grão Mogol, MG	930	adults and cacti
D63	Mucugê, BA	970	adults and cacti
D64	Andaraí, BA	300	adults
D65	Bonito, BA	*	adults and cacti
D66	9km W Morro do Chapéu, BA	1,120	adults and cacti
D67	20km W Morro do Chapéu, BA	900	adults and cacti
D68	Cafarnaum, BA	800	adults
D69	28km W Morro do Chapéu, BA	750	adults and cacti
D71	Morro do Chapéu, BA	1,350	adults and cacti
D72	10km S Morro do Chapéu, BA	1,180	adults
D70	30km S Morro do Chapéu, BA	*	cacti
D73	Cachoeira do Ferro Doido, 28km S Morro do Chapéu, BA	*	cacti

*. not measured

The imagoes were attracted with fermented bananas or oranges in plastic recipients hung on branches or placed among rocks (SENE **et al.**, 1981). The adult flies were captured with entomological nets, put in glass jars with culture medium and taken live to the laboratory, where they were identified. The larvae were collected in decaying cactus cladodes. In the laboratory, the cladodes were put in terraria with sand on the bottom and a fine net lid. The emerging flies were taken out with a suction pump.

Conspicuous species were identified using keys (FREIRE-MAIA & PAVAN, 1949; FROTA-PESSOA, 1954), descriptions (DOBZHANSKY & PAVAN, 1943; PAVAN & CUNHA, 1947; PAVAN, 1950), and the males of cryptic species were identified by the analysis of the terminalia (MAGALHÃES & BJÖRNBERG, 1957; VAL, 1982; VILELA, 1983; VILELA & BÄCHLI, 1990). Samples of the materials are deposited in the Museu de Zoologia da Universidade de São Paulo (MZSP).

RESULTS AND DISCUSSION

The results of the identification of the 28,796 imagoes collected with baits are shown in table II. Some species, of which only females were found, are shown as unidentified for lack of diagnostic characteristics, which are exclusive to males in the majority of the *Drosophila* species from the Neotropical region.

The results of the identification of the 5,189 individuals hatched in the laboratory from the cactus cladodes are shown in table III. The use of cladodes as a breeding site has already been recorded for the species of the *buzzatii* cluster, which are *D. borborema, D. buzzatii* and the polytypic species *D. serido* (PEREIRA **et al.**, 1983). This is the first record of this substrate as the breeding site for several other species.

Twenty-three species were recognized among the 33,985 flies collected in the northern region of the "Cadeia do Espinhaço" (see tables I, II and appendix), six being introduced and seventeen native to the morphoclimatic areas of South America.

Table II. Number of adult individuals collected in the northern area of the Espinhaço Range, in 1990, by species or species group of *Drosophila.*

group	species	D54	D63	D64	D65	D66	D67	D68	D69	D71	D72	TOTAL
annulimana	unidentified	2	0	0	0	0	0	0	0	0	0	2
cardini	*D. cardini*	6,710	907	396	71	6	6	9	0	0	9	8,114
	D. polymorpha	37	0	0	0	0	0	0	0	0	0	37
guarani	*D. ornatifrons*	0	18	0	0	1	0	0	0	9	3	31
immigrans	*D. immigrans*	0	2	2	14	0	0	1	0	1	0	20
repleta	*D. borborema*	143	2	0	0	0	0	0	0	0	0	145
	D. buzzatii	18	0	0	0	0	0	0	9	0	0	27
	D. hydei	1,855	14	9	18	0	0	8	288	27	366	2,585
	D. mercatorum	1,765	704	90	490	141	286	568	0	0	0	4,044
	D. serido	0	23	44	8	135	20	19	5	0	25	279
	D. serido-type C	577	40	0	0	0	0	0	0	48	29	694
tripunctata	*D. mediopunctata*	0	0	0	0	0	0	0	0	1	0	1
melanogaster	*D. malerkotliana*	322	4	48	0	2	0	0	0	0	0	376
	D. simulans	3,470	1,844	691	1,813	110	273	2,293	693	34	168	11,389
saltans	*D. prosaltans*	0	14	20	5	1	0	1	3	0	8	52
	D. sturtevanti	214	0	0	0	0	0	0	0	0	0	214
willistoni	*D. capricorni*	0	1	0	0	0	0	0	0	0	0	1
	D. nebulosa	19	42	2	0	7	0	4	4	8	0	86
	unidentified	30	9	2	2	0	0	3	0	0	0	46
Ungrouped	*D. buscki*	16	0	0	0	3	0	0	0	0	0	19
	D. impudica	0	67	8	0	0	0	2	0	0	0	77
	D. latifasciaeformis	344	0	5	0	0	0	0	0	0	0	349
	D. pallidipennis	197	2	0	1	0	0	1	0	0	1	202
	Unidentified	0	0	1	0	0	0	1	0	4	0	6
	TOTAL	15,719	3,693	1,318	2,422	406	585	2,910	1,002	132	609	28,796

Table III. Number of individuals, belonging to genus *Drosophila* hatched in the laboratory from cladodes collected in the "Cadeia do Espinhaço", in 1990.

group	species	D54	D63	D65	D66	D67	D69	D71	D70	D73	TOTAL
repleta	*D. hydei*	4	0	3	0	0	0	0	0	0	7
	D. mercatorum	18	51	112	5	0	0	0	0	0	186
	D. nigricruria	3	0	0	0	0	0	0	0	0	3
	D. rosinae	0	17	0	0	0	0	0	0	0	17
	*buzzatii**	2,166	179	0	45	28	0	32	75	53	2,578
melanogaster	*D.malerkotliana*	58	0	0	0	0	0	0	0	0	58
	D. simulans	5	104	2, 185	0	0	0	0	0	0	2,294
saltans	*D. sturtevanti*	13	0	1	0	0	0	0	0	0	14
willistoni	*D. nebulosa*	0	0	0	0	0	9	0	0	0	9
Ungrouped	*D. latifasciaeformis*	23	0	0	0	0	0	0	0	0	23
	TOTAL	2,290	351	2,301	50	28	9	32	75	53	5,189

*. *D. buzzatii, D. borborema, D. serido and D. serido*-C type were identified from the "*buzzatii* cluster".

Some considerations about each of the species collected are presented below, in alphabetical order according to the group to which they belong to. The subgenera are ordered in the text according to their relative importance to the neotropics (*Drosophila, Sophophora, Dorsilopha,* and *Scaptodrosophila*).

Subgenus *Drosophila*

The *cardini* group. This group includes 16 species, 8 of which are endemic to the Caribbean (HEED & RUSSELL, 1971). Two species belonging to this group were detected in the northern region of the "Cadeia do Espinhaço". *D. cardini* was collected at nearly all the sites visited, confirming the affinity of the species with open vegetation (SENE **et al.**, 1980; TIDON-SKLORZ **et al.**, 1994). This species represented 42.7% of collected adults in the county of Grão Mogol, in the state of Minas Gerais (MG). *D. polymorpha* made up roughly 0.1% of adults captured in the wild. It is found mainly in forests and its distribution appears to be limited by dry conditions (PAVAN, 1959; SENE **et al.**, 1980).

The *guarani* group. *D. ornatifrons* (= *D. guarani*, synonym in VILELA & BÄCHLI, 1990) represented about 0.1% of the adults collected. It has been collected from the "Serra do Cipó", which is the first record outside the Atlantic forest (TIDON-SKLORZ **et al.**, 1994), the only morphoclimatic region where it had been found previously (SENE **et al.**, 1980).

The *immigrans* group. *Drosophila immigrans* is an introduced and cosmopolitan species, the only one in this group which occurs in the Neotropical region. This species had been previously collected in association with man and in areas of "cerrados" and forests and was never recorded in the "caatingas" or dunes (SENE **et al.**, 1980). In the northern region of the "Cadeia do Espinhaço" it was found at low frequency (0.1%).

The *repleta* group. This group, comprising 91 species, is the largest in the Neotropical region (VILELA & BÄCHLI, 1990). Eight species from this group were collected in the "Cadeia do Espinhaço". Two (*D. rosinae* and *D. nigricruria*) are represented only by laboratory-hatched individuals from decaying cactus.

D. borborema is considered an endemic species of the "caatinga" (VILELA **et al.**, 1983) where is it fairly common, and made up 0.5% of the collected adults. Of the 145 adults of this species captured in the wild 143 came from Grão Mogol (MG) and are the first record of this species south of the State of Bahia (BA), outside the characteristic "caatinga" environment.

D. buzzatii is a cactophilic species, probably originated in the Argentinean chaco, and introduced to different continents. Only 27 adults were found in almost 30,000 adults captured in the wild, of which 1,145 belonged to the *buzzatii* cluster. This data confirmed early findings (VILELA **et al.**, 1983; BARKER **et al.**, 1985; FIGUEIREDO & SENE, 1992), showing this species to be rare outside the Chaco, where is it fairly common (VILELA **et al.**, 1980).

D. hydei represented 9% of the adults captured in the wild, most from the county of Grão Mogol, MG. The opportunism of this cosmopolitan species, usually associated with urban environments, is emphasized with this first record of *D. hydei* in cactus. The species probably originated in Mexico.

D. mercatorum accounted for 14% of adults captured in the wild, and 3.6% of those hatched from decaying cactus in the laboratory. It is a generalist species and hatching from cacti is part of its opportunist strategy. It is found in different phytogeographic formations, frequently in the "cerrados" but not in the Atlantic forest (VILELA **et al.**, 1983).

D. nigricruria was collected at low frequency in the "cerrados", leading VILELA **et al.** (1983) to suggest that it might not be a true cactophilic species. More recently, this species was recorded in forests in the interior of São Paulo (TIDON-SKLORZ & SENE, 1992) and Minas Gerais states (TIDON-SKLORZ **et al.**, 1994). The present work recorded the hatching of three individuals of this species from cacti, indicating that *D. nigricruria* may have an affinity for cacti although being more plentiful forests.

D. rosinae, in spite of belonging to the subgroup *fasciola* which prefers a forest habitat, had already been found in the "caatingas" (VILELA **et al.**, 1983). No adult of this species was captured in the wild and the seventeen individuals identified in this work emerged from the cladodes of decaying cacti brought from Mucugê, BA (D63). This is the first record of the breeding site for this species and it is the second species of the *fasciola* subgroup to be associated with cactus (the first was *D. onca*, SENE **et al.**, 1977). These ecological affinities of breeding site reinforce the phylogenetic connection between this predominantly forest subgroup and the *mulleri* subgroup formed by dry area and semi desert cactophilic species (WASSERMAN, 1962, 1982; THROCKMORTON, 1975).

D. serido is a cactophilic species of wide and fragmented distribution, mainly occurring in the "caatingas" and along sand bars, and absent in the "cerrados". The differentiation observed in *D. serido* has been studied by SENE **et al.** (1982, 1988). They suggest that this is a polytypic species and that some of its populations seem to be reproductively isolated from others. This species made up 0.97% of the flies collected in this area.

D. serido-C type (type C aedeagus carrier, SILVA & SENE, 1991), described as a new species in TIDON-SKLORZ & SENE (in press), represented 2.41% of the collected flies. The distribution of this new species is apparently restricted to high fields in the "Cadeia do Espinhaço". It also hatched from cactus.

The *tripunctata* group. Includes 56 nominal species (VILELA, 1992) which are quite abundant in forest environments, absent in the "caatingas" and present at low frequencies in the "cerrados" and dunes (SENE **et al.**, 1980). Only one male of this group, from species *D. mediopunctata*, was found.

Ungrouped species. *D. impudica* (= *D. para*, synonym in VILELA & BÄCHLI, 1990) is found in various morphoclimatic areas in South America, but always in small numbers. This species accounted for 0.3% of collected adults, most from Mucugê (Bahia). *D. pallidipennis* represented only 0.7% of the collected flies. This species is present in various types of environments, but has always been collected at low frequencies.

Subgenus *Sophophora*

The *melanogaster* group. With **ca.** 160 species described and probably of Southeast Asian origin, this group includes 5 species which were introduced into several regions of the world and became cosmopolitan or subcosmopolitan (LEMEUNIER **et al.**, 1986; TODA, 1991). Two of them were collected in the northern area of the "Cadeia do Espinhaço". The invasive and opportunist characteristics of these species were demonstrated by the presence of their larvae in neotropical cactus cladodes.

D. malerkotliana is a recently introduced species in Brazil (VAL & SENE, 1980), widely distributed in areas of open vegetation including the southern area of the "Cadeia do Espinhaço" (TIDON-SKLORZ **et al.**, 1994). This species represented 1.3% of the adults captured in the wild, and was also found among imagoes which hatched from the cladodes taken to the laboratory.

D. simulans was the most frequently collected species in the northern area of the "Cadeia do Espinhaço", making up 39.6% of collected adults and 44.2% of the laboratory hatched from decaying cactus. Of the introduced species, it is the best adapted to the different phytogeographic regions in the neotropical areas. It is more common, however, in open areas (PERONDINI **et al.**, 1979).

The *saltans* group. This group is made up of 21 species according to VAL **et al.** (1981). Two were found in the northern area of the "Cadeia do Espinhaço". According to PAVAN (1959), these flies present marked seasonal variation and are very sensitive to collection techniques, as also confirmed by SENE **et al.** (1981).

D. prosaltans represented 0.2% of the collected adults. Although it occurs in different morphoclimatic domains, and generally at low frequencies, it is a species with greater affinity to the "cerrados" (SENE **et al.**, 1980).

D. sturtevanti accounted for 0.7% of adult individuals captured in the wild and 0.3% of those hatched from cladodes in the laboratory. It is a species of wide distribution occurring in practically all phytogeographic formations from Mexico to Brazil, including the Caribbean. However, it is more frequent in the "cerrados" (SENE **et al.**, 1980).

The *willistoni* group. This practically neotropical group includes 23 species according VAL **et al.** (1981). Only 2 of them were identified at species level in the

northern area of the "Cadeia do Espinhaço", in addition to an unknown number of cryptic species of the *willistoni* subgroup.

D. capricorni was represented by only one individual. This species is mainly found in forest regions (SENE **et al.**, 1980), but it had been recorded before in the southern area of the "Cadeia do Espinhaço" (TIDON-SKLORZ **et al.**, 1994).

D. nebulosa is found mainly in the cerrados, where it is the most common species. Eighty-six individuals representing 0.3% of the adults captured in the wild were recorded. Nine of the imagoes hatched in the laboratory from cactus belonged to this species. This is the first record of this breeding site for *D. nebulosa*.

Flies from the *willistoni* subgroup (*D. willistoni, D. paulistorum, D. equinoxialis* e *D. tropicalis*) were not identified at the level of species, and correspond to the "unidentified" category of the *willistoni* group. They are cryptic and represent 0.2% of the total of adults captured in the wild. TIDON-SKLORZ **et al.** (1994) recorded the presence of this group in the "Serra do Cipó", at a frequency of 8.0%. According to the literature (SENE **et al.**, 1980; TIDON-SKLORZ & SENE, 1992), low humidity may be a limiting factor for the species of this subgroup. It is likely that at least two species are present: *D. paulistorum* and *D. willistoni*.

Subgenus *Dorsilopha*

According to TODA (1986), the subgenus *Dorsilopha* is of eastern origin and consists of 3 species, one of which, *D. busckii*, has become cosmopolitan. In Brazil, this introduced species is seldom encountered in natural environments and its distribution is limited to open formations and to areas modified by man. *D. busckii* was present in our collections at low frequencies (0.1%).

Subgenus *Scaptodrosophila*

D. latifasciaeformis is an introduced species (SENE **et al.**, 1980) and its frequency among the adults collected in the northern area of the "Cadeia do Espinhaço" was 1.2%. This was the first time this species was found associated with cactus, representing 0.4% of the laboratory hatched individuals. Although absent in the south of Brazil, it is a widely distributed species in various types of vegetation.

CONCLUSIONS

D. serido - C type was the only endemism established (TIDON-SKLORZ & SENE, in press), although the fauna is rich in relation to the size of the researched area.

The introduced species (*D. busckii, D. hydei, D. immigrans, D. latifaciaeformis, D. malerkotliana* e *D. simulans*) comprised 26% of the total number of species and 50% of the individuals collected. They began to appear in this area after the arrival of man, altering the composition of the *Drosophila* fauna in the region. Native fauna is mainly made up of species with greater affinity for "cerrados" and "caatingas".

Among the six introduced species found, four were observed hatching from decomposed cacti. Of the 17 native species, only nine emerged from the cladodes and at least four of them are considered cactophilic (*D. borborema, D. buzzatii, D. serido* and *D. serido*-C type). This reinforces the hypothesis that the introduced species are more generalist, pre-adapted to exploit the available resources in the invaded environment.

This is the first record of the breeding site of larvae for *D. rosinae, D. nigricruria* and *D. hydei,* belonging to the *repleta* group. It is also the first breeding record of the introduced species in South American cacti.

Acknowledgments. To N.M. Diniz; P. R. Epifânio; J.L. Julio; M.H. Manfrin; F.C. Nather; E.A. Baruque; A.C. Sene and F.M. Sklorz, for several different reasons. This work was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Financiadora de Estudos e Projetos (FINEP) and Universidade de São Paulo (USP).

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Appendix

List of *Drosophila* species mentioned in the text.

Drosophila Fallen, 1823
cardini group
D. cardini Sturtevant, 1916
D. polymorpha Dobzhansky & Pavan, 1943
guarani group
D. ornatifrons Duda, 1927 (=*D. guarani* Dobzhansky & Pavan, 1943)
immigrans group
D. immigrans Sturtevant, 1921
repleta group
D. borborema Vilela & Sene, 1977
D. buzzatii Patterson & Wheeler, 1942
D. hydei Sturtevant, 1921
D. mercatorum Patterson & Wheeler, 1942
D. nigricruria Patterson & Mainland, 1943
D. rosinae Vilela, 1983
D. serido Vilela & Sene, 1977
tripunctata group
D. mediopunctata Dobzhansky & Pavan, 1943
melanogaster group
D. malerkotliana Parshad & Paika, 1964
D. simulans Sturtevant, 1919
saltans group
D. prosaltans Duda, 1927
D. sturtevanti Duda, 1927
willistoni group
D. capricorni Dobzhansky & Pavan, 1943
D. nebulosa Sturtevant, 1916
willistoni subgroup
D. equinoxialis Dobzhansky, 1946
D. paulistorum Dobzhansky & Pavan, 1943
D. tropicalis Burla & Cunha, 1949
D. willistoni Sturtevant, 1916
Ungrouped
D. busckii Coquillett, 1910
D. impudica Duda, 1927 (= *D. para* Pavan & Burla, 1950)
D. latifasciaeformis Duda, 1940
D. pallidipennis Dobzhansky & Pavan, 1943

Recebido em 22.12.1993; aceito em 11.07.1994